NATIONAL BUREAU OF STANDARDS REPORT

6158

INTERLABORATORY INTERCOMPARISONS

OF

500-WATT TUNGSTEN-FILAMENT STANDARDS

OF LUMINOUS FLUX

by

Velma I. Burns

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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Abstract

A group of six inside-frosted and seven clear 500-watt lamps were measured by eight laboratories. The average luminous flux was 9647 lumens for the frosted lamps and 9544 lumens for the clear lamps. The average of the percent deviations from the overall average for the eight laboratories was .39% in the case of the inside frosted lamps and .34% in the case of the clear lamps.

I. Introduction

This intercomparison was undertaken to determine the uniformity of measurements of luminous flux for these types of lamps at the participating laboratories. The laboratories participating and the order of reading are as follows:

- I. Champion Lamp Works
- II(a). Sylvania Electric Products, Inc. (using 60 in. sphere 3 runs)
- II(b). Sylvania Electric Products, Inc. (using 100 in. sphere 2 runs)
- III. Electrical Testing Laboratories, Inc.
- IV. Westinghouse Lamp Division
- V. Duro Test Corporation
- VI. General Electric Company
- VII. National Bureau of Standards
- VIII. Electrical Testing Laboratories, Inc.
- IX. Sylvania Electric Products, Inc.
- X. Interlectric Corporation
- XI. Champion Lamp Works

The order in which the laboratories made their readings was chosen to reduce shipment of the lamps as much as possible. Each laboratory followed its own customary procedure in making the measurements. The Electrical Testing Laboratories Inc., Sylvania Electric Products Inc., and Champion Lamp Works measured the lamps more than once and all values reported are listed in the tables which follow. Only the first values reported by these laboratories, however, were used in calculating averages for all laboratories.

II. Results of Measurements

The values of current reported by each laboratory are given in Table I. The values of luminous flux are given in Table II. For all measurements the lamps were operated at 120 volts.

The range of the average values in percent are shown below.

Lamp Type	Current Range	Luminous Flux Range
Frosted	0.53%	1.61%
Clear	.72%	1.54%

An analysis of the results was made as follows:

Let

F = Luminous flux measured value.

F_{La} = Luminous flux measured by a given laboratory, L, for a given lamp, a.

$\bar{F}$ = Average of all luminous flux measurements made by all the laboratories for one type of lamp.

$\bar{F}_L$ = Average luminous flux for all the lamps of a given type measured at a given laboratory.

$\bar{F}_a$ = Average of luminous flux measurements made on a given lamp at all the laboratories.

Δ = deviations

$\Delta_L = \bar{F}_L - \bar{F}$

$\Delta_a = \bar{F}_a - \bar{F}$

The residual error, v, for each lamp measured at each laboratory, was found by the following formula

$$v = F_{La} - \bar{F} - \Delta_L - \Delta_a$$

The probable error in the average value, $\bar{F}_L$, is given by the expression

$$PE = \frac{0.8453 \sum v}{n \sqrt{n-1}}$$

where n is the number of observations.

The huge error in $\bar{F}_L$ is

$$HE = 4.9 \times PE$$

The huge error for each laboratory is a measure of how closely the average reported by that laboratory ($\bar{F}_L$) represents measurements made at that laboratory. The huge error for each laboratory in percent of $\bar{F}$ is shown in Table II. It can be shown that laboratories having $\%\Delta_L$ larger than %HE may be on a basis of measurement different from that of the other laboratories.

III. Discussion

There is fair agreement between the participating laboratories on values of current and luminous flux. The range in the average values of current reported for frosted lamps is 0.53% of the average values reported by all laboratories. For the clear lamps the range is 0.72%. The range in the average values of luminous flux reported for the frosted lamps is 1.61% of the average of values reported by all laboratories and for the clear lamps the range is 1.54%.

By treating the average values reported by each of the eight laboratories as a series of eight measurements and by using the formula

$$HE = 4.9 \frac{0.8453 \Sigma \Delta_L}{n \sqrt{n-1}}$$

the huge error in the average for all the laboratories ($\bar{F}$) was found to be 0.61% for the frosted lamps and 0.53% for the clear lamps. Then by using the same series of measurements and the formula

$$HE = 4.9 \frac{0.8453 \Sigma \Delta_L}{\sqrt{n(n-1)}}$$

the huge error in the average reported by any one laboratory was found to be 1.71% for the frosted lamps and 1.51% for the clear lamps.

The average percent deviation in luminous flux values reported ($\bar{\Delta}_L$) is 0.39% for the frosted lamps and 0.34% for the clear lamps.

Table I

Interlaboratory Intercomparisons of Current in Amperes of 500-Watt Lamps Operated at 120 volts

Lamp No.	Champ.	Syl.	ETL	West.	Duro.	GE	NBS	Int.	Ave	ETL	Syl.	Champ.
Order of reading	I	II	III	IV	V	VI	VII	X		VIII	IX	XI
Inside Frosted												
NBS4265	4.07	4.063	4.060	4.05	4.07	4.06	4.056	4.05	4.060	4.060	4.056	4.048
NBS4266	4.16	4.167	4.155	4.14	4.16	4.15	4.149	4.14	4.153	4.150	4.146	4.145
NBS4267	4.165	4.161	4.155	4.14	4.16	4.15	4.149	4.14	4.152	4.150	4.144	4.145
NBS4268	4.165	4.170	4.165	4.15	4.18	4.16	4.155	4.15	4.162	4.150	4.149	4.153
NBS4269	4.18	4.170	4.165	4.15	4.17	4.16	4.162	4.16	4.165	4.160	4.158	4.158
NBS4270	4.155	4.152	4.155	4.13	4.15	4.14	4.144	4.14	4.146	4.140	4.140	4.135
Ave of 6	4.149	4.147	4.142	4.127	4.148	4.137	4.136	4.130	4.140	4.135	4.132	4.131
Δ	+.009	+.007	+.002	-.013	+.008	-.003	-.004	-.010		-.005	-.008	-.009
$\%\Delta$	+.22	+.17	+.05	-.31	+.19	-.07	-.10	-.24		-.12	-.19	-.22
Clear												
NBS4271	4.135	4.127	4.115	4.10	4.12	4.11	4.112	4.10	4.115	4.110	4.108	4.108
NBS4272	4.16	4.160	4.150	4.13	4.16	4.14	4.137	4.14	4.147	4.140	4.131	4.135
NBS4273	4.14	4.136	4.135	4.11	4.14	4.12	4.120	4.12	4.128	4.120	4.117	4.138
NBS4274	4.105	4.108	4.100	4.08	4.11	4.10	4.096	4.10	4.100	4.095	4.094	4.103
NBS4275	4.17	4.158	4.150	4.14	4.16	4.13	4.197	4.15	4.157	4.150	4.146	4.158
NBS4276	4.16	4.153	4.145	4.13	4.15	4.14	4.138	4.14	4.144	4.140	4.136	4.138
NBS4277	4.155	4.147	4.140	4.12	4.15	4.14	4.134	4.13	4.140	4.135	4.130	4.135
Ave of 7	4.146	4.141	4.134	4.116	4.141	4.126	4.133	4.126	4.133	4.127	4.123	4.131
Δ	+.013	+.008	+.001	-.017	+.008	-.007	.000	-.007		-.006	-.010	-.002
$\%\Delta$	+.31	+.19	+.02	-.41	+.19	-.17	0	-.17		-.14	-.24	-.05

Table II

Interlaboratory Intercomparisons of Luminous Flux in Lumens, F_{La} of 500-Watt Lamps Operated at 120 Volts

Inside Frosted

Lab (L) Order of reading Lamp No.	Champ. I	Syl. II(a)	ETL III	West. IV	Duro. V	GE VI	NBS VII	Int. X	Ave $\bar{F}_a$	Δ_a $(\bar{F}_a-\bar{F})$	Syl. 100 in sphere II(b)	ETL VIII	Syl. IX	Champ. XI
NBS4265	9634	9682	9790	9744	9703	9734	9680	9728	9712	+ 65	9683	9810	9745	9760
NBS4266	9431	9506	9550	9508	9503	9502	9479	9491	9496	-151	9496	9670	9537	9536
NBS4267	9602	9601	9760	9674	9672	9696	9672	9664	9668	+ 21	9634	9770	9761	9748
NBS4268	9442	9521	9680	9673	9643	9616	9570	9584	9591	- 56	9545	9620	9622	9656
NBS4269	9813	9836	9840	9844	9870	9852	9827	9740	9828	+181	9806	9900	9860	9884
NBS4270	9499	9513	9730	9595	9628	9618	9622	9500	9588	- 59	9532	9660	9649	9624
$\bar{F}_L$	9570	9610	9725	9673	9670	9670	9642	9618	$9647=\bar{F}$		9616	9738	9696	9701
$\Delta_L=\bar{F}_L-\bar{F}$	-77	-37	+78	+26	+23	+23	-5	-29			-31	+91	+49	+54
$\%\Delta_L$	-.80	-.38	+.81	+.27	+.24	+.24	-.05	-.30			-.32	+.94	+.51	+.56
%HE	.54	.64	.59	.40	.45	.10	.35	.74			.30	.64	.35	.25

Clear

Lab (L) Order of reading Lamp No.	Champ. I	Syl. II(a)	ETL III	West. IV	Duro. V	GE VI	NBS VII	Int. X	Ave $\bar{F}_a$	Δ_a $(\bar{F}_a-\bar{F})$	Syl. 100 in sphere II(b)	ETL VIII	Syl. IX	Champ. XI
NBS4271	9572	9451	9570	9586	9583	9557	9512	9528	9545	+ 1	9450	9570	9579	9584
NBS4272	9822	9782	9890	9807	9787	9802	9747	9812	9806	+262	9786	9840	9823	9852
NBS4273	9666	9586	9760	9634	9687	9693	9609	9636	9659	+115	9617	9660	9663	9708
NBS4274	9461	9396	9480	9447	9517	9583	9453	9466	9475	- 69	9398	9470	9501	9574
NBS4275	9459	9389	9540	9523	9545	9522	9470	9533	9498	- 46	9356	9550	9522	9566
NBS4276	9255	9184	9340	9317	9342	9330	9276	9282	9291	-253	9168	9310	9320	9360
NBS4277	9440	9458	9590	9519	9612	9582	9531	9553	9535	- 9	9452	9560	9555	9590
$\bar{F}_L$	9525	9464	9596	9548	9582	9581	9514	9544	$9544=\bar{F}$		9461	9566	9566	9605
$\Delta_L=\bar{F}_L-\bar{F}$	-19	-80	+52	+4	+38	+37	-30	0			-83	+22	+22	+61
$\%\Delta_L$	-.20	-.84	+.54	+.04	+.40	+.39	-.31	.00			-.87	+.23	+.23	+.64
%HE	.59	.35	.45	.40	.35	.40	.25	.30			.54	.25	.15	.30

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